NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

NMFA NUCLEAR MATERIALS FOCUS AREA

University of Utah

Nuclear Isotopic Dilution of Highly Enriched Uranium by Dry Blending via the RM-2 Mill Technology

Technology Need:

There is a need within the DOE complex to disposition excess fissile materials. In particular, INEEL has stored 1,700 kg of off-spec Highly Enriched Uranium (HEU) in its CPP-651 vault facility. This material has a high Uranium 235 (^{235}U) enrichment and is considered to be "off-spec" due to the presence of various uranium isotopes that emit high-energy gamma radiation; it also is contaminated with fission products which further complicates exposure issues for storage and off-site shipment. It does not meet ORNL acceptance criteria nor can it be accommodated advantageously at the SRS dilution facility.

Technology Description:

The University of Utah believes that isotopic dilution of HEU to typically less than 20% by dry blending is the key to solving the dispositioning issue (i.e., proliferation) posed by HEU stored at INEEL. It reduces storage costs because it no longer requires Category I and II safeguards and security (S&S) measures, it promotes ALARA (as low as reasonably achievable) exposure for both the shipper and receiver because the source term has been reduced and normalized, and most importantly, it could uncouple this material from the schedule of the SRS processing facilities by allowing it to be processed at other HEU dilution sites.

A unique irreversible dry blending process has been developed at the University of Utah, using a grinding mill called the RM-2 mill. The RM-2 mill design enables operation at very high centrifugal fields not possible with other mill technologies. Due to the energy generated by this centrifugal field, particle reduction to ultra-fine sizes occurs very rapidly. The RM-2 mill, because of this ability to generate high energy in the mill, is ideally suited for small diameter mills required to address the criticality safety issues associated with HEU. If this technology is proven to be adaptable to dispositioning ^{235}U, it may also work for other excess fissile materials and provide a nonaqueous option that could be significantly less costly. Furthermore, a dry process can be sized to meet site-specific throughput rates, is expected to require minimal hot cell space, and should provide unique schedule flexibility, because material dispositioning would be de-coupled from the retirement schedule for existing aqueous processing facilities.

For the dry blending process, the RM-2 mill simultaneously grinds and blends two materials. The RM-2 mill is a ball mill, operating in a very high gravitational field. The canister is filled with 2-mm stainless steel or alumina grinding media, with the feed stock powders to a filling of about 35 to 45 percent of canister volume. Then the canister is fitted in the mill cage, which is powered by an electric motor. The spinning motion of the can on its own axis, and rotating motion of the canister on the axis of the central shaft, produces centrifugal force in excess of 40Gs (Gravitational Fields). Separation of the grinding media is straightforward and will be implemented depending on the results of a cost/risk analysis; i.e., recycling minimizes both the cost of the grinding media itself, as well as its waste disposal costs; if it is sent with the package, contamination control is minimized by leaving the grinding media sealed inside the canister.

In 1998, the RM-2 milling process was tested with surrogate materials (titanium dioxide and titanium monoxide), with different particle sizes and densities, to assess the effectiveness of the milling and blending process. These tests proved to be very successful and demonstrated adequate blending and mixing (i.e., no methods were identified to easily separate and

concentrate one titanium compound from the other), and similar results are expected for uranium oxide.

Benefits:

▸Provides adequate mixing and blending, while minimizing processing time, equipment, and waste generation; eliminates current need for transitioning from a solid phase to an aqueous phase and then back to a solid phase.

▸Compact equipment size enables efficient processing of small inventories and adaptation to a mobile system is possible.

▸Off-site shipments will not require S&S protection, and receipt will not require a Category I vault storage capability; shipping costs and storage costs prior to processing will be minimized.

▸Increases the number of potential HEU and Plutonium (Pu) applications and the number of potential receiver/processor sites for disposal or recycle.

Status and Accomplishments:

This project continues the development of a nonaqueous technique to dilute the enrichment of ^{235}U to less than weapons-grade concentrations. Tests will be conducted with combinations of depleted uranium (DU) and natural uranium (NU) and no HEU will be used. Initial testing will demonstrate irreversible mixing and blending. Additional testing will be conducted to further optimize production parameters and improve design features related to container size, milling times, radiological contamination control, worker exposures, accountability, remote handling, packaging, control features, and criticality safety. Successful demonstration of the process with uranium will help build a technology that could apply to other nuclear materials that are in various oxide forms (e.g., ^{233}U, Pu, Neptunium).

Current testing has two primary objectives: 1) demonstrate the feasibility of using the RM-2 mill to grind and blend uranium oxide streams with different ^{235}U enrichments, different particle size distributions, and different densities into a uniformly mixed oxide that prevents the separation and enrichment of ^{235}U as an oxide; and 2) optimize the basic process relative to throughput rates, safety, safeguards, ALARA, and other INEEL site-specific constraints for equipment sizes. On DOE approval, the University of Utah will develop a conceptual design for application at the Idaho Nuclear Technology Engineering Center (INTEC).

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Online Resources:

Office of Science and Technology, Technology Management System (TMS), Tech ID # 3172
http://ost.em.doe.gov/tms

The National Energy Technology Laboratory Internet address is http://www.netl.doe.gov